



Canadian Grain
Commission

Commission canadienne
des grains



Grain Research Laboratory

1987-1988 Report

Canada

Grain Research Laboratory | 61st Report 1987-1988

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*Pilot malting at the Grain Research Laboratory -
removing malted barley from the germination drum.*

cover illustration

Canadian Grain Commission Grain Research Laboratory

July 29, 1988

Canadian Grain Commission
Winnipeg, Manitoba

Commissioners:

I am pleased to submit the following report reviewing the activities of the Grain Research Laboratory for the period April 1, 1987 to March 31, 1988.

Respectfully submitted,

K.H. TIPPLES
Director

Introduction

The Grain Research Laboratory (GRL), the scientific division of the Canadian Grain Commission, was established in 1913. It functions under Section 12 of the Canada Grain Act (1971) according to which the Commission shall *"undertake, sponsor and promote research in relation to grain and grain products and, in so doing, maintain an efficient and adequately equipped laboratory."*

All Laboratory activities continue to serve one or both of two very clear basic objectives - **quality assurance for Canadian grain** and **market support**. Highlights of the year's activities are described in this report.

This year's report contains two special feature articles. The first describes the Laboratory's close interaction with the Canadian International Grains Institute. The second is a history of the development of improved malting barley varieties in Canada. The author, Dr. D.E. LaBerge, has traced this development from the introduction of barley seed from France to New France in 1606 to the present expansion in production of improved two-row and six-row malting varieties.

The Grain Research Laboratory is proud to have played a small part in this evolutionary process.



Dr. S.J. Symons and Mrs. N.L. Morgan.

During the year Mrs. Doreen Routley, Assistant Director (Administration), resigned to take up a position with the Department of National Defence in Suffield, Alberta. She was succeeded by Mrs. N.L. Morgan.

Dr. S.J. Symons joined the staff as a research scientist and will be using a recently purchased image analyzer to work in the field of grain biology.



Dr. R. Matsuo was honored by the American Association of Cereal Chemists at the Annual Conference in November 1987 when he was designated a Fellow of the Association.



Dr. C.J. Dempster retired after 39 years of service and at the beginning of the year accepted a term position to edit a special index of GRL publications for the Laboratory's 75th Anniversary.

The Laboratory's permanent staff totalled 97 at March 31, 1988. In addition, 10 casual assistants were employed for varying periods in the service, research and office sections of the Laboratory.

There now follows a report of GRL research and related scientific activities during 1987-88.

Quality Assurance Activities

All export cargo shipments of wheat, barley, oats, rye and canola and all cargo shipments (both domestic and export) of soybeans and corn involving 1,647 cargoes for the 1986-87 crop year were screened to confirm freedom from contamination by pesticide residues. Selected cargo loadings of wheat, barley, corn and soybeans involving 489 shipments for the 1986-87 crop year were also screened for the presence of mycotoxins.

Monitoring of bi-weekly composites of carlots of wheat unloaded at terminal elevators was continued, using the Falling Number test, to indicate any evidence of sprout damage.

Because of inquiries into the effects of possible contamination of 1987-grown Ontario wheat with "tombstone" kernels, a special investigation was launched into levels of the major *Fusarium* toxins in composites of daily deliveries of Canada Eastern white winter wheat to terminal elevators.

In response to interest in the possibility of unregistered rapeseed varieties entering the grain handling system as canola, weekly carlot-unload average samples from all terminal elevators were screened for erucic acid and glucosinolate content. Results indicated that admixture was not a concern.

cargo and carlot monitoring

The Grain Research Laboratory is responsible for the maintenance of moisture meters used at the Canadian Grain Commission during official grading of grain. This work has two aspects: **calibration and meter testing.**

For converting meter reading to an estimate of the actual moisture content, separate calibration equations must be developed for each type of grain; and since the relationship between meter reading and moisture content is influenced by factors such as seed size and density, these calibrations must be continually checked for validity and updated as necessary.

There are currently 44 conversion tables (generated using the calibration equations) for 25 types and classes of grain. Effective August of 1987, an updated conversion table for use with the

Model 919/3.5 meter was issued for Eastern Canadian corn.

Moisture meters used in Canadian Grain Commission offices are monitored for accuracy and precision through the use of bi-weekly check-test samples. Meters not functioning satisfactorily are recalled for servicing.



Air-oven moisture content determination for calibration of Model 919 meter.

technical services



Varietal identification by chemical analysis.

Other technical service work performed this year included registered variety verification by chemical analysis of samples submitted by the Grain Inspection Division of the Canadian Grain Commission and quality testing of samples submitted by various segments of the grain industry through the Grain Inspection Division on a fee-for-service basis.

cultivar evaluation

Evaluation of milling and baking quality, semolina milling and pasta-making quality for a large number of plant breeders' wheat lines entered in various Western Cooperative Tests was completed and reports were submitted to the Subcommittee on Wheat of the Western Expert Committee on Grain Quality. Quality testing was also carried out on several Quebec-grown varieties and on samples obtained from a special semi-dwarf wheat study in which the Laboratory collaborated.

The Grain Research Laboratory continued to provide essential quality evaluation support to Canadian malting barley variety development programs. The highlight of the year was the fruition of past efforts to evaluate and release a superior two-rowed malting cultivar that

would offer barley growers in Western Canada wider access to world markets. This goal was achieved when Harrington accounted for 43% of the area seeded to malting barley, replacing Bonanza (24% of malting barley seeded area) as the principal Canadian malting cultivar.

Plant-scale commercial testing by domestic malting and brewing industries was successfully completed on another two-rowed malting cultivar, Ellice. This variety will make possible the expansion of the production area for two-rowed malting barleys into eastern Saskatchewan and into Manitoba for the first time. A six-rowed selection, BT 477, has performed extremely well compared with Bonanza and was approved for registration as a new malting cultivar.

An important accomplishment this year was the development of a rapid analytical technique for the analysis of chlorophyll content in canola. This enabled the Committee on Western Grain Standards to recommend adoption of chlorophyll content as a grading factor for rapeseed - replacing the less accurate and less objective "green seed" measurement currently in use. Part of this work involved providing assistance to several commercial grain organizations in setting up and using chlorophyll analyzers.

In order to determine the existence of any potential hazards associated with *Fusarium* head blight infections in wheat grown in Manitoba in 1987, samples identified by the Grain Inspection Division of the Canadian Grain Commission as containing affected kernels were tested for the presence of *Fusarium* trichothecene toxins. Samples of Quebec-grown wheat were also analyzed as part of these quality assurance initiatives.

In studies of the effect of vitreousness on durum wheat processing quality, it has been established that retention of vitreous kernel requirements for top grades of CWAD wheat is justified to ensure adequate protein levels for satisfactory pasta cooking quality.

The influence of midge damage on red spring wheat milling and baking quality has been determined, as has the effect of frost and immaturity on red spring wheat quality and wheat protein properties.

A preliminary examination of vomitoxin (DON) contaminated corn revealed that corn kernels containing high levels of DON had distinct visible symptoms that could be used for identifying highly contaminated kernels in commercial parcels. An encouraging correlation between DON concentration measured by chemical analysis and DON level estimated by NIR spectrometry was obtained in a study of Canada Eastern white winter wheat. Our understanding of the relationships between percent "tombstone" kernels in a sample and DON concentration was also improved, as was our understanding of the relationship between the occurrence of HT-2 toxin in wheat and the occurrence of different strains of *Fusarium* microorganisms.

Further to the development of the GRL "Paste Viscosity Indicator" as a more rapid and cheap alternative for measuring sprout damage, three working instruments for measuring viscosity during the heating of ground grain-water slurries were constructed and tested during the year.

grading factor studies

The work in grain biology centered on investigations into

- the association of physical symptoms of *Fusarium* infections in corn with the presence of mycotoxins and
- the relationship between degrees of visible sprouting and alpha-amylase enzyme activity in red spring wheat.

Considerable time was also devoted to coordinating the Canadian Grain Commission - Agriculture Canada survey of restricted weed seeds in export cargoes. This survey of over 1,800 samples taken from export cargo loadings of red spring wheat, amber durum wheat and barley will provide the first substantial data for Canadian grain cargoes on the frequency of occurrence and level of contamination of weed seeds subject to importer's quarantine.

Market Support Activities

Surveys of the average quality of different grades of various classes of Canadian grains and oilseeds harvested each growing season are a major endeavour of the Laboratory. An ever-increasing harvest survey load was completed and culminated in the publication of the new crop bulletins for wheat, canola, flax, sunflowers and soybeans.

Quality testing of cargo composites of different grades of the various classes of Canadian grains and oilseeds is another major activity. The appearance of the quarterly cargo bulletins for red spring

wheat and semi-annual cargo bulletins for amber durum wheat has now been upgraded and publication is in a new, easier-to-read format. Interested organizations and individuals throughout the world receive these publications which document the high quality for which Canadian grain is renowned. Quality analysis of composite samples of other grains and oilseeds was continued. This included monthly analysis of composite samples of canola cargoes for oil and protein content, fatty acid composition, glucosinolates and chlorophyll.

harvest and cargo surveys

The Director and several Laboratory scientists took part in various technical missions and visits to South Korea, Uruguay, Mexico, Singapore, Japan, People's Republic of China, Cyprus, Brazil and Italy. Such visits often require extensive laboratory studies related to specific milling and baking conditions used in each market country. Technical visits of this nature enable us to provide expert advice on the best classes and grades of wheat to be used and also to determine if processing conditions (e.g., mixing and oxidation level) should be modified in order to optimize baking performance.

Grain Research Laboratory scientists worked with Canadian Wheat Board specialists in coordinating commercial quality testing programs for both red and white cultivars intended for the Canada Prairie Spring class of wheat. Throughout the year numerous lectures, practical demonstration sessions, tours, etc. were organized to assist the Canadian International Grains Institute with its courses for Canadian and foreign participants. As well, the Canadian International Development Agency

requested and received technical assistance from the GRL in connection with shipments of food-aid grain to Ivory Coast, Senegal and Mali. Results from a study into the effect of sprouted kernels on the spaghetti quality of Canadian amber durum wheat provided essential information for discussions with the Japanese Food Agency on this topic and for determining possible directions that grade specifications may follow in the future.

technical consultations, missions and studies



It has become increasingly important for us to understand and evaluate the influence of the biochemical components present in flour on production of various wheat-based end-products other than Western-style bread. In the past year, a test-baking procedure for the preparation of Chinese steam bread has been developed, and the HunterLab Labscan II spectrophotometer has been set up to measure the color and brightness of Chinese noodles.

A special two-week program was provided for three commercial bread production personnel from the Sam Lip Company, Korea. The object of the program was to demonstrate and discuss the advantages of using Canadian wheat

in modern short-process baking procedures. These advantages include higher bread yield and shorter mixing time. A study was also completed on the milling and baking quality of Canadian and Brazilian wheat processed using Brazilian specifications.

Pre-testing of the quality of cargoes of No. 3 Canada Western red spring wheat shipped to Colombia and Peru was carried out prior to Grain Research Laboratory scientists making visits to bakeries in Cali and Lima. As a result, baking studies into the use of high fat and sugar formulations, such as those often utilized in Colombia, are now in progress.



*R.H. Kilborn and J.E. Dexter
in South America.*

Research Activities

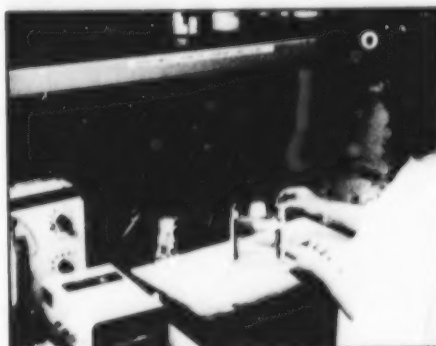
High performance liquid chromatography (HPLC) has been utilized to determine the ratio of subunits in the glutenin protein fraction, which appears to be related to the gas-retaining properties of dough made from breadwheat flour. This technique is also being used to examine changes occurring to wheat proteins associated with sprouting. Reversed-phase HPLC is being applied in the analysis of the technologically important cereal enzymes alpha- and beta-amylase.

Completed projects in the area of protein research included measurement of heat damage effects on gluten functionality and determination of the effect of various inorganic salts on protein characteristics and baking quality.

Sprout damage continued to be the topic of several research projects:

- investigation of the relative contribution of slightly- and severely-sprouted kernels to alpha-amylase activity;
- examination of two procedures (the Paste Viscosity Indicator, developed at the GRL, and a colorimetric method developed in Australia) for their potential in rapid operational monitoring of alpha-amylase activity; and
- studies on the effects of high alpha-amylase activity on the quality of spaghetti processed from durum semolina.

Significant progress on varietal identification by chemical analysis has been achieved. Good resolution in the separation of wheat proteins using two-dimensional electrophoresis has resulted in the detection of over 1,300 components for individual wheat varieties. This technique has potential for not only identifying mixtures of varieties but also relating wheat quality factors to specific protein components. In another approach, computer-assisted analysis has been successfully applied to the identification of Canadian wheat cultivars through reversed-phase HPLC. Another sophisticated technique, SDS-gradient polyacrylamide gel electrophoresis, is used in our Laboratory for identifying Canadian wheat and barley varieties in samples submitted by the Grain Inspection Division.

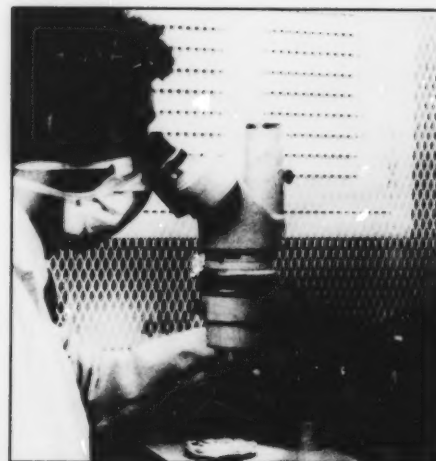


Pouring a gel for variety identification analysis.

wheat

Milling and baking research completed during this time period included studies of the effect of roll-flute orientation on durum wheat semolina quality and experimental milling performance; the particle size properties of flour produced by smooth-roll grinding of hard red spring wheat farina; and the effect of starch damage and water absorption on the alveogram properties of flour milled from Canadian wheat.

Mycology studies into the fusarium head blight disease in wheat have resulted in the identification of the main species involved, the classes of wheat most susceptible to infection and the growing areas where the toxin-producing species are most likely to occur. Information is also being compiled on the factors contributing to the severity of infection.



Identification of microflora using microscopy.

barley

The presence of alpha-amylase and starch granules in the outer pericarp of immature barley kernels was confirmed. This low *pI* alpha-amylase and the starch granules disappeared at about the same stage of kernel development. Numerous very small granules remained in the inner pericarp (chlorophyll containing tissue) until a later stage of kernel development.

An enzyme that solubilizes (1→3)(1→4) beta-glucan in barley endosperms has been partially purified from barley kernels.

Chromatographic and microscopic techniques were used to follow the degradation of beta-glucan and starch in barley kernels treated with high energy radiation. Although starch granules from treated samples appeared to be intact when examined by light and scanning electron microscopy, they disintegrated when heated in water, suggesting that covalent bonds had been broken by the radiation treatment.



Preparing a barley sample for microscopy.

Examination of developing barley kernels by light, fluorescence and scanning electron microscopy showed that degraded starch granules were present in localized areas of the endosperm adjacent to the embryo. These degraded granules extended only one or two cells deep into the endosperm and were present even in mature barley kernels. Therefore, the presence of degraded starch granules in mature barley endosperm does not indicate, necessarily, that the barley had sprouted.

High performance liquid chromatography studies revealed that chlorophyll 'a' and chlorophyll 'b' were present in canola seed in a ratio of about 3:1 and not 10:1 as previously had been published. Studies on processed oil showed that most of the chlorophyll 'a' could be accounted for as pheophytin 'a' but chlorophyll 'b' was changed during processing into other as yet undetermined pigments.

Low *pl* alpha-amylase and small starch granules were detected in the hulls of developing seeds of *B. campestris* and *B. napus*. The enzyme was similar to that present in the pericarp tissue of immature barley and wheat kernels.

Other highlights during the year were

- the analysis of the composition of a cloudy deposit in canola oil;
- the determination of the stability of linolenic acid when flaxseed was used as an adjunct in breadmaking;
- and the development of a simple assay for seed size in canola.

oilseeds

analytical methodology

Improvements were made to the Laboratory's methods for determining pesticide residues and mycotoxins in grains to permit the GRL to keep pace with increasing demands for these types of analyses. With incorporation of an automated gel permeation chromatography-concentrative evaporation apparatus, sample preparation throughput capability has almost doubled for both categories of screening test. In addition, the number of pesticides that can be monitored in a single gas chromatography scan has been almost doubled with use of selected ion monitoring-mass selective detection (SIM-MSD). Significant improvements in both sensitivity and selectivity have also been realized in our pesticide residue method with the SIM-MSD approach.

Studies with a near-infrared transmission instrument indicated its potential as a more accurate moisture tester for corn than the capacitance-principle Model 919 moisture meter.

Use of a near-infrared reflectance (NIR) technique for rapid prediction of vomitoxin content in ground grain has been found to be more accurate than counting "tombstone" kernels and shows distinct promise as an operational tool.

Application of NIR methodology to rapid measurement of alpha-amylase activity showed much less promise for samples from the 1987 harvest than was the case for 1986 harvest survey samples.

Examination of the "Glutomatic" instrument as a potential replacement for the "Theby" gluten washer for the determination of wet gluten content of flour at the Grain Research Laboratory has resulted in the "Glutomatic" technique being used routinely for amber durum wheat samples. Tests with other classes of wheat are continuing.

Total digestible fibre (TDF) content is reputed to represent the carbohydrates present in feeds and foods which are digestible by ruminants but not by monogastrics, including man. The TDF test includes determination of neutral detergent fibre (NDF) as an estimate of insoluble fibre, and a soluble fibre determination which follows enzymic removal of starch. During 1987, the Grain Research Laboratory participated in a collaborative study carried out in North America. The objective of this work was to develop a near-infrared reflectance spectroscopy calibration for TDF, NDF and soluble fractions.

Interaction of the Grain Research Laboratory with the Canadian International Grains Institute

The Grain Research Laboratory (GRL) has had a long working relationship with the Canadian International Grains Institute (CIGI), an institutional facility offering instructional courses in grain handling, marketing and technology. Interaction with the Institute has fallen into three main categories.

• **Provision of resource persons and facilities for lectures and demonstrations to participants of courses** developed by CIGI at the

request of the Canadian Wheat Board (CWB), the Canadian Grain Commission (CGC) and other organizations involved with the export of Canadian grains, oilseeds or their products. Such participants have interestingly diverse backgrounds. They range from domestic producers to foreign end-product users of Canadian grains. On many occasions, GRL personnel have served in a dual role as both participants and resource persons. In their capacity as participants, they have played an active role in making the other course members feel welcome and assisting them in obtaining information on the quality of Canadian grain by putting them in contact with the appropriate "expert". Demonstrations of end-product processing are frequently carried out in the GRL and tours are provided to give an overview of the instruments used to carry out the measurement of quality as well as to indicate the research programs that are underway to monitor and improve quality.

• **Customer service.** The GRL and CIGI have frequently been involved with team approaches to servicing overseas customers of Canadian grains. These programs have usually been in response to CWB requests and are concerned with increasing the awareness of buyers to the quality attributes of Canadian grains and ensuring that the correct processing conditions are used with them.

• **Collaborative research** instituted by the GRL. Baking research programs at the GRL are normally carried out on a laboratory scale in one of four sections.

- The routine baking section is limited to pup loaves (100 g flour).
- The breadmaking research section generally produces loaves weighing about 300 g.
- Another laboratory, specializing in research on breads unique to different parts of the world, works on a scale similar to commercial production but is limited by mixer size.
- Finally, there is a section carrying out research on a laboratory scale of products other than traditional bread, i.e., noodles, Chinese steamed buns, chapatis, arabic flat-breads.

For such research on secondary processing, it is useful also to evaluate the findings of small-scale research on a larger industrial scale. Such testing can be carried out by personnel of the food technology section of CIGI using their "commercial-scale" equipment in which larger doughs can be handled. In this regard, the GRL has designed equipment to facilitate studies by CIGI using such equipment. Thus various measuring devices have been built to monitor the energy and mixing characteristics of doughs using a commercial spiral mixer or the Tweedy mixer commonly used in the United Kingdom. A commercial dough brake has been designed complete with electronics for measuring and setting roll gaps. The GRL 1000 mixer, with a capacity to mix a dough using up to 1 kg of flour (enough for three 455 g loaves), was developed for CIGI.

With regard to milling, the GRL routinely uses laboratory-scale mills such as the Allis-Chalmers mill, the Brabender

Quadrumat Junior mill, an experimental mill designed by Ross Machine and Mill Company, Oklahoma City, Oklahoma, as well as a larger-scale pilot mill with a milling capacity of 270 kg/hr which bridges the gap between laboratory and commercial milling (see the 1982 GRL Annual Report for full details on such mills). Research studies carried out using these mills is complemented by commercial-scale milling equipment at CIGI, capable of milling nine tonnes per 24 hours.

In recent years, the type of on-going projects which stand out include:

- i) the evaluation of new types of wheats for their potential in milling and secondary processing;
- ii) evaluation of existing wheat types for preparing end-products relevant to the country of a particular customer;
- iii) evaluation of quality factors that are important for various wheat end-products.

In addition to the above main programs, there are other interactions between the two organizations: technical support staff as well as research scientists may attend CIGI courses to broaden their base of knowledge concerning aspects of the cereal industry with which they are not familiar; equipment is occasionally shared in emergency situations; and the exchange of information (accumulated over many years by individuals, of both organizations, in their area of expertise) on an informal basis to assist in problem-solving and decision-making.

The GRL has been heavily committed to CIGI technical programs and cooperative ventures in customer assurance and GRL-supervised research since the inception of CIGI in 1972. The involvement has grown with the increased growth and development of CIGI as an instructional facility. It would be impractical to mention all such involvement in this report. However, for the period April 1986 to April 1988, some typical examples are as follows:

- Over 40 major lectures were given to overseas and domestic participants attending courses in Winnipeg. Popular lectures which have been presented include:

- Canadian Wheat: Properties, functionality and end-uses
- Effect of degrading factors on end-use quality of Canadian wheat, oilseed products and malting barley.
- Development of new wheat varieties in Canada: Screening for end-use quality

- Three courses which illustrate GRL involvement during the last few years are:

i) *The International Flour Technology course* which is designed for technical managers as well as administrators in the wheat processing industry. For this course, major lectures such as those previously indicated were given by GRL research scientists. Tours emphasizing the Milling, Baking and Near-Infrared Spectroscopy (NIRS) Analysis sections of the Laboratory were given, and practical sessions were provided on pasta-manufacturing in the Durum section of the Laboratory.

ii) *The International Feed and Oilseed course* which provides a broad understanding of the Canadian feed and oilseed industries. Topics include grain and oilseed handling, transportation, feed nutrition, feed manufacturing, management of poultry and animals, and oilseed

crushing, extraction and processing. GRL staff, particularly from the oilseeds section, have contributed to this program.

iii) *The Grain Quality Measurement Technology course*. This program was developed to familiarize senior grain inspectors with potential new instruments which might assist them in grain grading. In this course, various instruments and techniques (such as NIRS, variety identification by electrophoresis or HPLC, measurement of sprout damage) which are used in the GRL to measure quality were examined in depth by the participants. As well as talks on the effect of grading factors on quality, information on the programs involving monitoring for mould, fusarium head blight and toxic chemical contaminants was presented.

- Many bilateral CIGI programs held both in Canada and abroad involved the expertise of the GRL. These included participants from Iraq, Mexico, Korea, Philippines, China, etc.

In particular, there have been a number of bilateral programs with the People's Republic of China. Programs in which the GRL has been heavily involved have been for personnel of the state administration of Import and Export Commodity Inspection Bureau (SACI), which is an organization that bears some similarity to the Canadian Grain Commission in that part of its responsibilities involves the inspection and quality control of cereals entering or leaving China. As early as 1982, a one-week training course was put on in Hangzhou, and was an introduction to the laboratory testing procedures used at the GRL. Since then, there have been a number of visits exchanged by personnel of both organizations. In 1985, three candidates were selected by SACI to have an intensive training program in laboratory procedures. The program lasted two months and covered all aspects of the quality control procedures in the GRL as well as further exposure to processing in the milling and baking facilities of CIGI and in Canadian processing plants. A follow-up program will be held this spring in Dalian, Peoples' Republic of China, with emphasis on milling and rheological

testing of flour. Such cooperation, facilitated by CIGI, is very important in ensuring that our respective organizations are carrying out quality testing in the same way. This in turn will help to prevent any difficulties that could arise due to misinterpretation of results.



Representatives from the Import and Export Commodity Inspection Bureau, P.R.C. spent 6 weeks at the GRL in a training program (left to right, standing: Xu Hui Min, Wang De Fu, Hau Tain Liang; seated: J.E. Kruger and R.R. Matsuo of the GRL).

• In the area of malting barley technology, GRL expertise has also been called upon. For example, in October of 1986, a GRL scientist was in China as part of a CIGI-sponsored malting and brewing technology team. In Canada in August of 1987, three engineers from the Peoples' Republic of China spent five weeks in Canada exploring Canadian malting and brewing technology. Again, there was a substantial commitment to this program by the barley section of the GRL.

• In the area of customer service, there have been numerous missions to overseas customers by joint GRL-CIGI teams, particularly to Southeast Asia and South America. One example of this is a CWB/CGC/CIGI mission to the Republic of Korea in early 1987 for on-site testing of the milling and processing quality of Canadian wheat. This program continued in the summer of 1987 with the visit of three Koreans who spent two weeks in the GRL and CIGI baking laboratories evaluating the various breadmaking methods and learning how to produce an optimal loaf of bread from Canadian wheat. Visits to bakeries in eastern Canada rounded out their program.

Finally, mention should be made of the excellent cooperation of CIGI in GRL-organized research projects. Scientific papers which best illustrate this cooperation are:

- PRESTON, K.R., MATSUO, R.R., DEXTER, J.E., TWEED, A.R., KILBORN, R.H. and TULLY, D. The suitability of various Canadian wheats for steamed bread and noodle processing for the People's Republic of China. Canadian Institute of Food Science and Technology Journal 19, 114, 1986.
- DEXTER, J.E., PRESTON, K.R., TWEED, A.R., KILBORN, R.H. and TIPPLES, K.H. Relationship of flour starch damage and flour protein to the quality of Brazilian-style hearth bread and remix pan bread produced from hard red spring wheat. Cereal Foods World 30(8), 511, 1985.



Malting Barley Improvement in Canada

An historical review by Dr. Donald E. LaBerge

Introduction of barley to Canada

Records are fragmentary with respect to the introduction of barley into Canada. The first Governor of New France, Samuel de Champlain, brought seed from France in 1606 which was planted at Port Royal in Acadia. Champlain imported more seed in 1610 which was grown on his Seigniorie near Quebec City. The purpose of these introductions was to determine if barley suitable for the manufacture of beer could be grown in the New World. French colonists objected to high taxes assessed on beer imported from France and wanted to have beer produced in the colonies. The success of these projects is not recorded.

In 1664, Jean Talon, the Intendant of New France, recognized the need to limit the general use of "ardent spirits" imported in large quantities from the West Indies. He applied to Louis XIV for

funds to erect a brewery which was built in Quebec City in 1668. However, when Frontenac arrived in 1672 as Governor of New France, he converted the brewery into a prison.

France ceded her possessions in Canada to England under the terms of the Treaty of Paris in 1763. As a result, there was a sharp increase of British immigrants into Upper Canada, and these settlers brought barley grown in their homeland. The brewing industry in England was well established and only barley suited for brewing was grown in Britain. The principal introductions were two-rowed selections of two sub-types: *Thorpe*, with a short compact head, and *Chevalier*, with a long nodding head. Selections of these sub-types were widely-grown in Upper Canada well into the 19th century.

The early malting and brewing industries

The malting and brewing industries in their early stages of development in Canada could best be described as "cottage" industries. They were small and scattered to meet the needs of local people. Each brewery operated its own malthouse with the brewmaster in charge of barley purchases and the malting operation. Barley was grown within

hauling distance of the brewery, and each brewmaster selected the type and variety preferred by him and encouraged its production. Therefore, brewmasters were an important factor in barley improvement. Brewmasters tended to encourage the production of varieties that they and their forebears were accustomed to in Europe.



While barley varieties differed from district to district, they were mostly two-rowed of either the Thorpe or Chevalier types. Thus, in the barley-growing areas of Ontario, farmers who preferred Thorpe varieties could choose from *Canadian Thorpe*, *Duckbill*, *Silver King*, *Prize Prolific* or *Golden Grain*, while other farmers discussed the merits of *English Chevalier*, *Scottish Chevalier*, *French Chevalier*, *Danish Chevalier*, *Swedish Chevalier* or *Kinver Chevalier*. If there was any difference among these two types, it probably resulted from natural selection assisted by farmers who screened their seed or, in some cases, through selections made by seed merchants.

Original malthouses were rudimentary "floor" maltings, and germination required from 8 to 12 days. There was virtually no control of steeping, aeration, moisture or heat and, as a result, malting was often discontinued during summer months. It was the development of pneumatic maltings in the 1880's that largely led to the establishment of malthouses operating independently of breweries. The "Galland" malting system provided for control of air movement, air moisture and germination temperature, and the "Saladin" system further provided for mechanical turning of the germination bed.

Prior to 1860, the beer business in North America was hardly of a scale to be classified as an industry. Whiskey and rum were inexpensive at 25 to 30 cents per gallon and placed beer at a considerable disadvantage given the generally poor economic and social conditions of the times and the difficulty of packaging and transporting beer.

Many things occurred in the years between 1860 and 1895 to alter this situation. The brewing industry changed dramatically with the advent of steam, electricity and refrigeration. When first introduced in the 1870's and 1880's, refrigeration was used to make artificial ice for cooling of fermentation and storage cellars, but it was soon realized that mechanical refrigeration could eliminate the need to store beer in underground cave cellars and allowed brewing to occur all year instead of just during the colder months. The first appreciation of the concepts of enzyme mediated reactions, the role of pure yeast cultures and the principles of pasteurization began to revolutionize the industry in scientific terms. The invention of the "crown cork" in 1892 allowed for the marketing of beer in bottles and revolutionized the methods for distributing beer products.



Temperance and prohibition

The temperance movement had its origin in Canada in the early 19th century when social aid was negligible and when most Canadians were self-employed as farmers, fishermen or small businessmen. By the mid-19th century, much urban poverty was perceived as caused by "drink", and there was a shift of mood from temperance as an individual decision to legal prohibition as a social issue.

Immigration levels from Europe were high in the later years of the 19th century, and per capita consumption of liquor was increasing steadily. Various religious, political and temperance groups encouraged beer consumption as a means to displace the popular use of distilled spirits. With the growth of the prohibition movement, many rural areas and small towns were encouraged to go "dry", forcing the building of larger breweries in major cities and hastening the demise of smaller local breweries. Despite these changes, beer consumption continued to increase.

Malting barley trade with the U.S.A.

With this background and these changes, it is interesting to trace the development of barley trade between Canada and the United States from around 1850 to 1900. The first free trade agreement between Canada and the U.S. was known as the Reciprocity Treaty and was signed in 1854. At this time, barley production in the U.S. was not keeping

pace with demand. The land along the north shore of Lake Ontario from Toronto to Kingston was noted for good quality malting barley. A vigorous barley trade developed, and Ontario growers received good prices for their product which provided further incentive for growers to improve methods of malting barley production.

When World War I broke out, the temperance movement was close to its peak, and campaigns for prohibition were mounted in the name of patriotism that rendered opposition to prohibition almost impossible. The provinces one by one introduced legislation to prohibit retail sale of intoxicating liquor. It was only for a very brief time in 1918 that the federal government actually prohibited manufacture and importation of alcohol in Canada as a war measure, and the order-in-council was revoked when the war ended. Thus wineries, distilleries and breweries that were licensed properly continued to operate as legal entities throughout almost the entire period with sales restricted to "outside the province". Most provincial legislation was abandoned from 1921 to 1930 in favor of provincial government regulation of sales that are variable from province to province to this day.



In 1866, the U.S. government unilaterally abrogated the Reciprocity Treaty and imposed an import tax of 15 cents per bushel on barley. The quality of Ontario-grown two-rowed barley was such that trade with the U.S. continued to expand. As a result, during the ten years preceding 1890, the U.S. imported an average of 10 million bushels of barley per year from Canada.

The McKinley Tariff, enacted in 1890, increased the import tax on barley to 30 cents per bushel. This was a protectionist measure to shelter growers, particularly in Wisconsin, that destroyed Canada-U.S. trade in malting barley. With excess production in Ontario, barley could not be sold at any price, and many growers switched to dairy herds and hog production. This also was the demise of two-rowed malting barley in Canada. As quality was no longer important, varieties became mixed, barley was grown with other cereals as a mixed grain for livestock feed and contamination with weed seeds was a problem.

Many Ontario growers migrated to Western Canada and became the wheat growers of the Prairies. In the period

from 1880 to 1916, grain production progressed by leaps and bounds in Western Canada. Wheat production was the goal of every settler. Barley was a scavenger crop grown when soil fertility was depleted or weeds a problem, and so growing of high class barley became a lost art.

It is against this Canadian background that the U.S. government in 1919 introduced the Volstead Act as the Eighteenth Amendment to the U.S. constitution prohibiting the manufacture, distribution and consumption of alcoholic beverages. United States maltsters immediately attempted an invasion of the Canadian malting, brewing and distilling industries to sell their products - with little success. More successful was the smuggling of liquor legally produced in Canada to our "dry" neighbor to the south. This was the period of "rum-running", "bootlegging", illicit "moonshine" and "speakeasies". When prohibition was repealed in the U.S. in 1933, malting barley development and production were in chaos, and the malting and brewing industries in the U.S. were under-developed.



Barley improvement • the first era

The first efforts of barley improvement in Canada occurred at the Ontario Agricultural College (O.A.C.) in Guelph. This university was founded in 1874, and it was a few years later when Professor C.E. Zavitz, Head of Field Husbandry, began to import foreign barley varieties for field testing in Ontario. The first release from this program was a six-rowed feed barley named "*Mandscheuri*" that Zavitz first introduced from Russia for testing in 1889. *Mandscheuri* had mixed aleurone colors with about a 50% mixture of white and blue kernels. As "*Mandscheuri*" was difficult to spell and pronounce, the name was corrupted variously as *Manshury*, *Mansury* and *Mensury*.

In 1903, Zavitz planted 10,000 seeds of *Mandscheuri* with one foot spacings. It was from this experiment that seed from one plant was selected and designated as O.A.C. No. 21. Further testing confirmed the improved yield and good straw strength of this blue-aleuroned selection, and OAC 21 was released to growers in 1910 as a feed barley. Zavitz opposed the use of intoxicating beverages and assumed that blue barleys would never be used for brewing. Ironically, OAC 21 eventually became the principal barley used in Canada for brewing.

Meanwhile, the Experimental Farms Act was passed by the Dominion Parliament in 1886. The first director of the Dominion Experimental Farm System, Dr. William Saunders, and later his son, Sir Charles Saunders, crossed barley varieties as a technique for crop improvement. This method proved successful for milling wheats, oats and feed barleys, but did not result in the release of a single malting barley variety until 1945 when Macdonald College released *Montcalm* as the first malting variety developed in Canada by hybrid crossing techniques.

The early work at the Central Experimental Farm in Ottawa did confirm that two-rowed varieties from other countries matured too late under Canadian conditions and tended to have weak straw compared with six-rowed varieties. As a result, improvement of six-rowed varieties was encouraged. Two further selections were made from *Mensury*. One was intended as a malting variety with a white aleurone and was named *Manchurian*. The other, intended as a feed variety, had a blue aleurone, and although initially called *Chinese*, it eventually became known as *Ottawa 60* or *Mensury Ottawa 60*.



Barley improvement • the second era

In the early 1920's, the barley situation in the Prairie Provinces had not improved. If varieties were pure when released to growers, they soon became mixed. There was little or no cash market in Western Canada, so barley was grown as livestock feed. Because of early maturity, barley was used as a weed-control crop and became further contaminated with weed seeds and volunteer grain.

In 1921, Canada Malting Co. Ltd. inaugurated a scheme to improve quality of substantial volumes of Canadian barley. With the cooperation of the Canadian Seed Growers Association, accredited varieties of barley were malted and tested for quality. In these early tests, the six-rowed, blue-aleuroned selections, OAC 21 and Mensury Ottawa 60, proved to have superior quality. Steps were taken to increase the supply of pure seed, particularly of OAC 21, over the period from 1924 to 1928. Registered seed was either given to selected growers for reproduction under contract to Canada Malting Co. Ltd., or the seed was sold at a nominal price to individual growers in the better barley areas.

Other steps were undertaken by Canada Malting Co. Ltd. to ensure a continuous supply of good malting barley for domestic industrial consumption. To make barley financially attractive to growers, selection premiums were paid for high-quality barley. Improved cultural techniques were encouraged by meetings with farm groups, articles in the agricultural press, publication and distribution of practical booklets on malting barley production and donation of cash prizes and trophies at important agricultural exhibitions.

Barley improvement was further encouraged by maltsters and brewers through financial contributions to agricultural colleges. At this time, each Prairie Province had well-established field crop departments within their agricultural faculties. Professor T.J. Harrison at the University of Manitoba was involved with the efforts of Canada Malting Co. Ltd. to improve barley quality. The need for small-scale malting equipment to evaluate large numbers of samples was recognized. Professor Harrison was the first person in Canada to design such equipment which was installed in his new Barley Laboratory in 1927 that allowed for complete malting independent of industry.



People, committees and organizations involved in barley improvement

In 1918, a meeting was convened in Winnipeg by the Dominion Department of Agriculture that included representatives of the grain trade, maltsters, universities and government. As a result of this meeting, the National Barley Committee was formed to consider steps to be taken to increase production, improve quality and increase markets for barley. Much of the work carried out by Canada Malting Co. Ltd. and Professor T.J. Harrison was with the support and cooperation of the National Barley Committee. This Committee strongly influenced the change in grade schedules in 1929 to better reflect market requirements for barley. The Canada Grain Act was altered to include statutory standards of malting quality for the top grades of barley. *As OAC 21 was by far the major variety grown in Canada and most widely purchased for malting, it was named as the statutory standard of quality for six-rowed varieties of barley.* Since 1929, a distinctive blue aleurone has been used in Canada to distinguish six-rowed malting barley from feed barleys having a white aleurone. *A rather obscure variety, Canadian Thorpe, was named as the statutory standard of quality for two-rowed varieties.*

By a fortunate coincidence, the new grade schedules were well-established and functioning effectively when prohibition was repealed in the U.S. in 1933; but thirteen years of national prohibition had seriously depressed the volume of barley and potential supplies of good malting varieties there. In the nine years following repeal (1933-1941), Canadian exports of malting barley to the U.S. averaged 3,300,000 bushels. In the following 9 years (1942-1950), this figure rose to an average of 16,700,000 bushels.

The revisions to the Canada Grain Act in 1929 included a provision for the Board of Grain Commissioners for Canada to appoint four assistant Commissioners to improve contact of Commissioners with grain producers. Professor T.J. Harrison was appointed Assistant Commissioner for Manitoba in 1930, and he remained in that position until 1948 when he became the first Managing Director of the newly-formed Barley Improvement Institute. His replacement in the Department of Field Husbandry at the University of Manitoba was Dr. G.P. McRostie.



Despite the good work initiated and sponsored by the National Barley Committee, the Committee was large, unwieldy and was dissolved in 1928. Another National Barley Committee was established in 1933 as a subcommittee of the National Advisory Committee on Agricultural Services. T.J. Harrison was named as chairman of the new National Barley Committee.

T.J. Harrison was truly a pioneer of barley research. Under his leadership, the National Barley Committee established sub-committees to address specific problems: plant breeding and production, marketing and transportation, cleaning and handling, barley feeding experiments and feed analysis, western barley grades and eastern barley grades. Of significance was the decision to turn over responsibility of research on malting barley to the Associate Committee on Grain Research of which T.J. Harrison was a member.

The Associate Committee on Grain Research was established in 1926 under the sponsorship of the National Research Council and the Dominion Department of Agriculture. The Committee met once or twice a year to focus on problems of hard red spring wheat and durum wheat quality and on problems associated with marketing of these commodities. When presented with the mandate to investigate malting barley, the Associate Committee on Grain Research established two subcommittees: Malting Barley Research

(1934) chaired by Dr. G.P. McRostie, and Methods for Experimental Malting and Malt Analysis (1935) chaired by Dr. J.A. Anderson.

The story of malting barley research in Canada cannot be told without giving special recognition to the exceptional talents and abilities of Dr. J. Ansel Anderson. He began his career in Ottawa in 1932 with the newly-formed Division of Biology and Agriculture, National Research Council. When given the assignment in 1934 to undertake fundamental research on malting barley, Dr. Anderson travelled extensively in Britain to learn of developments in that country, and he also visited universities in Manitoba, Minnesota and Wisconsin to evaluate laboratory malting equipment. Under his direction, new malting equipment was designed, constructed, installed and operational by 1936 in Ottawa. The intent was that fundamental studies on malting would be performed in Ottawa while the University of Manitoba would continue to conduct general investigations.

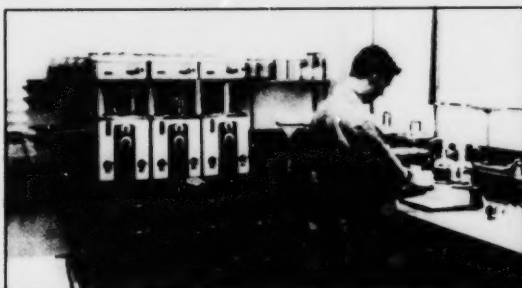
Dr. McRostie resigned as a Professor of Agronomy, University of Manitoba, to take up a similar position at the Ontario Agricultural College in 1936.

W.O.S. Meredith, who had spent two months in the Barley Laboratory at the University of Manitoba in 1936, was moved from Ottawa to Winnipeg in 1937 to coordinate the implementation of standard analytical procedures and malting methods between these two laboratories.

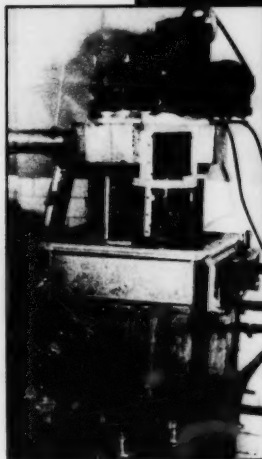


The malting equipment designed and installed in 1927 by Professor T.J. Harrison at the University of Manitoba performed yeoman service for ten years. In 1937 the germinator was modified, and a new steep-tank and kiln were constructed. The steep tank was replaced again in 1940 with a newer model, and a little later, a new germinator incorporating the best features of the Manitoba and Ottawa units was installed.

By the time that Dr. J.A. Anderson left the National Research Council in Ottawa in 1939 to become Chief Chemist of the Grain Research Laboratory, Board of Grain Commissioners for Canada, he and his colleagues had published 25 research papers. This work forms the basis of malting procedures and analytical methods still used in Canada to evaluate breeders' lines of barley for malting quality.



Malt analysis laboratory, circa 1961.



Prototype of vertical germinator, circa 1952.

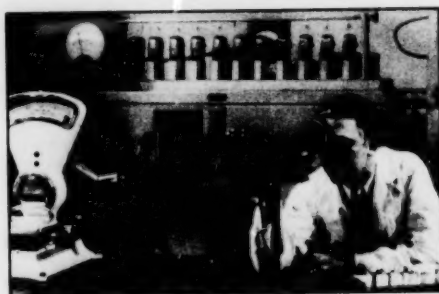


Pilot-scale kiln, circa 1961.



The influence of World War II on barley production in Canada

The operations and staff of the Barley Laboratory at the University of Manitoba were funded by the National Research Council (NRC) and were supervised by staff in Ottawa. With the outbreak of the Second World War, the Associate Committee on Grain Research concentrated its activities on research of national importance to the war effort. W.O.S. Meredith was seconded to the Grain Research Laboratory (GRL) in 1942, and later that year the staff and equipment were transferred from the university to the GRL. Also, in 1942, the Ottawa portion of the program was closed down, and the useful malting equipment was shipped to the GRL. Under the supervision of Dr. J.A. Anderson, the barley program at the GRL was funded by the NRC until 1945 when the GRL assumed responsibility for funding.



Malt laboratory, 1948 - refractometer for sugar analysis of malt extracts.

During the Second World War, normal production quotas of malt for customers were curtailed to meet other basic requirements of the war effort. Canada was very dependant on imports of cane sugar and natural rubber. Maltose sugar from malt was used as a partial substitute for cane sugar. Alcohol produced from malt was used as a base for production of synthetic rubber and a source of explosives. Malting capacity in Canada actually increased by 42% during the war years to meet the demands of high priority industries despite the loss of export markets for barley malt.

A fixed, low ceiling price was placed on barley for five crop years from 1942 to 1946. This removed the incentive for growers to produce high quality malting barley. In 1939 over 65% of the barley marketed was of good malting quality, and by the end of the war, only 2.5% of barley production was considered to be of malting quality. To remedy this situation, maltsters and brewers provided funds for the National Barley Committee to conduct a National Barley Contest awarding provincial and national cash prizes for growers who produced high quality malting barley. This program was initiated in 1946 and continued into the late 1950's and was considered a useful tool to emphasize the importance of quality of malting barley.



The National Barley Contest pre-dated the Barley Improvement Institute. In fact, the Barley Improvement Institute was an outgrowth of the contest. The National Advisory Committee on Agricultural Services had decided that the National Barley Committee was doing work outside the mandate of the Associate Committee on Grain Research. To ensure that the work of the National Barley Committee be carried on, maltsters and brewers organized and agreed to finance the Barley Improvement Institute which was chartered in 1948 and began operations in 1949 with T.J. Harrison at the helm. The National Barley Contest continued under the sponsorship of the Institute.



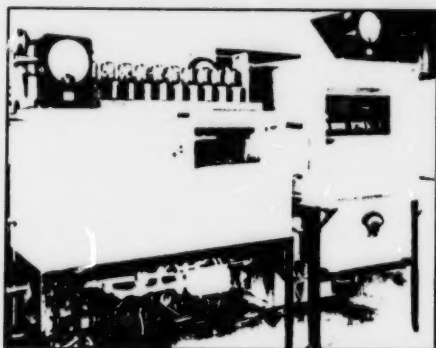
Standing (L. to R.): J.A. Anderson, T.J. Harrison, W.O.S. Meredith.
Seated: V.M. Bendelow.
Taken from Manitoba Industrial Topics, Vol. 9, No. 2, 1949, issued by the Industrial Development Board of Manitoba.

Post-war evolution of committee structures to evaluate malting and brewing quality of barley

In 1947, W.O.S. Meredith was given a year of absence to complete his PhD studies at the University of Minnesota. Upon his return to the GRL in 1948, Dr. Meredith was appointed to the Board of Directors of the Barley Improvement Institute together with Dr. J.A. Anderson. Thus began a close association between the GRL and the Institute to foster studies for the improvement of malting and brewing quality of Canadian barley cultivars that continues today.

V.M. Bendelow began his career as a chemist with the Barley Improvement Institute in 1948 with training in the GRL on the operation of micro-malting equipment during his first year of

service. The micro-malting equipment was operated jointly by the GRL and the Institute from 1948 to 1950, but the malting barley selection program was directed by V.M. Bendelow who, in fact, was an employee of the Dominion Department of Agriculture. With the increased demand for malting tests, the GRL was having difficulty conducting fundamental research. As a result, the malting equipment was moved to the premises of the Institute in 1951. It remained at the Institute until 1957 when V.M. Bendelow moved the operations to the Winnipeg Research Station, Dominion Department of Agriculture, where some of this equipment continues to be operational.



Micro-malting equipment used at the Grain Research Laboratory in the 1940's.

Meanwhile, the first pilot-scale drum malting equipment was designed, constructed, tested and operational in the GRL by 1956. In 1957, construction of a pilot brewery was completed on the premises of the Malting Barley Institute. For the first time, it was possible to obtain brewing data for malting barley varieties prior to licensing. To reflect its new role in the evaluation of malting cultivars, the name of the Institute was changed to the Brewing and Malting Barley Research Institute (BMBRI).

The BMBRI established a Technical Committee with representatives of the malting and brewing industries and of government to evaluate malting and brewing performance of barley selections undergoing pilot-scale testing. In turn,

the Technical Committee formed a smaller Sub-Committee on Pilot Brewing to ensure that the facilities operated by BMBRI conformed as closely as possible to pilot breweries operated by industry.

Collaborative Pilot-Scale Malting and Brewing Trials were established to evaluate advanced breeders' lines of malting barley. V.M. Bendelow, Winnipeg Research Station, had the responsibility for evaluating the malting quality of entries in national co-operative tests for two-rowed and six-rowed barley. Only the most promising entries in the Co-operative Tests were eligible for advancement to Collaborative Pilot-Scale Malting and Brewing Trials.

Collaborative barley plots are grown at four or five locations each year using one-fifth acre plots for each entry. In most years, all samples undergo pilot-scale malting at the GRL and pilot-scale brewing by BMBRI. The selections from one or two sites representing the best barley available are malted by industry and evaluated for brewing performance by each of the three major Canadian breweries and also by BMBRI. The Technical Committee of BMBRI evaluates the performance of each selection and prepares a report for the Subcommittee on Barley.



**Managing directors of the
Brewing and Malting Barley
Research Institute***

T.J. Harrison	1948-1958
M.G. Madden	1958-1961
B.B. Elliott	1962-1964
W.W. Sisler	1964-1987
N.T. Kendall	1987-

*Known as the
Barley Improvement Institute
from 1948 to 1957.

The Subcommittee on Barley was originally established by the Associate Committee on Grain Research. The Subcommittee is broadly-based with representation from government, universities and industry with the responsibility to evaluate data relating to all entries in national Co-operative Tests and in Collaborative Trials. The Associate Committee on Grain Research was the recommending committee for licensing, usually accepting the recommendations forwarded to it by its various subcommittees.

This is the system largely in place today to evaluate malting barley cultivars. Many changes in the intervening years have been cosmetic. For example, the Associate Committee on Grain Research became the "Canada Committees" in 1970 when the National Research Council ceded its responsibilities to the Department of Agriculture. With some restructuring, the committees became known as the "Expert Committees" in 1980 and the "Western Expert Committees" in 1987. The infrastructure of subcommittees remained relatively unchanged.

Dr. W.O.S. Meredith served for 24 years as chairman of the Subcommittee on Barley and for many years prior to 1950 as secretary of the Subcommittee. When he retired in 1974, the GRL had moved into the newly-built Canadian Grain Commission Building, and the opportunity was available to expand the malting facilities of the laboratory. Dr. D.E. LaBerge was placed in charge of Malting Barley Applied Research.

A decision was made for the GRL to re-assume responsibility for evaluating malting quality of entries in national Co-operative Tests. To this end, two complete sets of micro-malting equipment designed to malt 500 g samples were installed. The Western Co-operative Two-Row Barley Test was taken over by the GRL in 1979, and the Six-Row Barley Test became the responsibility of the GRL in 1985 when Dr. V.M. Bendelow retired from duties at the Winnipeg Research Station.

As a result of these changes, the Winnipeg Research Station has responsibility for early generation testing of malting barley selections and evaluation of entries in regional trials for advancement to national Co-operative Tests. The GRL conducts trials of barley selections entered in national Co-operative Tests and, through the Subcommittee on Barley, cooperates in decisions leading to selections to be advanced to Collaborative Pilot-Scale Malting and Brewing Trials. The BMBRI coordinates Collaborative Trials and arranges for pilot-scale malting and brewing trials within governmental and industrial facilities. With close cooperation with the Technical Committee of BMBRI, the Subcommittee on Barley forwards recommendations to the Western Expert Committee on Grain Quality with advice on the suitability for potential malting barleys to be registered for the Prairie Provinces.



In recent years, malting cultivars approved for registration are given an interim registration that must be renewed yearly. This allows for limited amounts of pedigreed seed to be produced, and for the Canadian Wheat Board to grow a new malting barley cultivar under contract to the Board for purposes of market development. In this way, railway

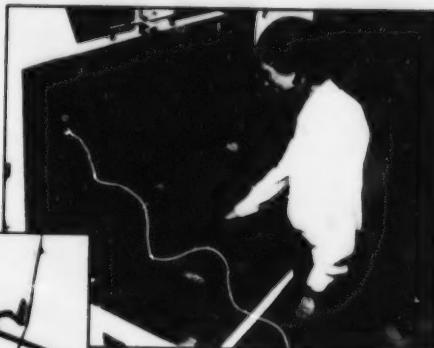
carlots are made available for commercial testing by industry. If the program proves successful after three years of commercial testing, the malting cultivar is given permanent registration. Interim registration will not be renewed if any major problems are encountered during plant-scale testing.

This review of historical developments that led to the current system for evaluating malting cultivars for registration has focussed on certain individuals and their role to improve Canadian malting barley. Many other individuals are not recognized who contributed substantially to various efforts to improve malting barley. As well, although possibly of greater importance, this review does not include the important research that contributed to malting barley improvement. That must be the subject of another review.

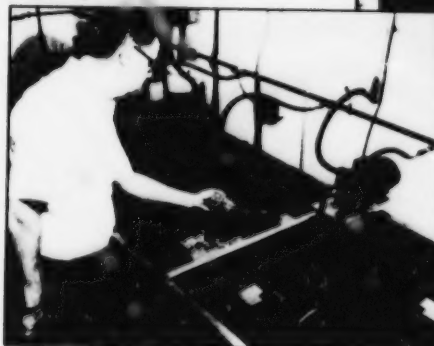


**malting at the
Grain Research
Laboratory
today**

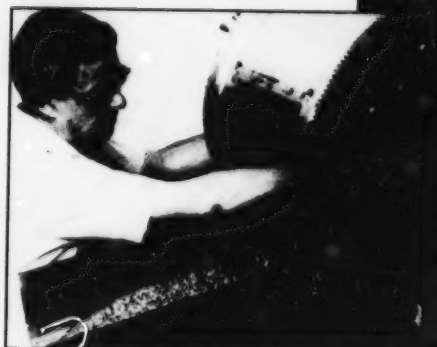
*Steep tank in the "Seeger"
micro-malting plant.*



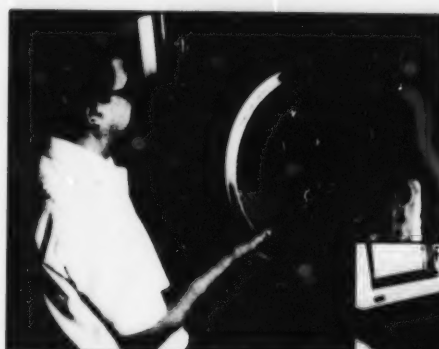
*Pilot malting -
Moisture-conditioning
barley in the aerated
steeping tanks.*



*Pilot malting - Steeped
barley entering the drum
germination chamber.*

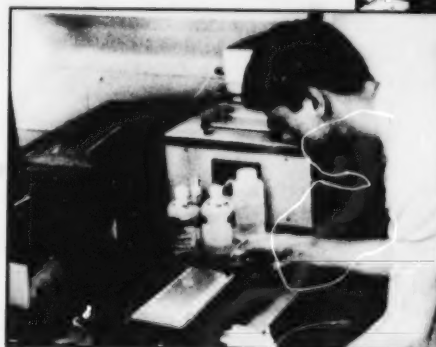


*Pilot malting - Germinated
barley being removed from
drum prior to kilning.*



Pilot malting - Dried, germinated barley (malt) being removed from the kiln.

Malt analysis laboratory.



Analysis of alpha-amylase in malt.



Analysis of beta-amylases in barley and malt.



Barley improvement • the recent era

A. Six-Rowed Barley

In the early part of the twentieth century, western Canadian farmers tended to grow barley for malting rather than for feed. However, OAC 21 was the best of a poor lot of malting varieties available at the time and farmers who grew it must have felt it dominated by default. Because of its heavily barbed awn, it was extremely uncomfortable to handle. It was susceptible to diseases - the smuts, rusts and root-rots. Its straw was generally so weakened by leaf and stem diseases it collapsed before harvest. If it survived to harvest, it usually lodged or shattered. The kernels peeled on threshing. Little wonder the complaint, 'I can't grow barley' was heard from farmers well into the 1950's. Nevertheless, OAC 21 occupied over 30% of the area in barley production throughout most of its 40-year history.

Efforts to replace OAC 21 were dominated by a desire to produce a smooth-awned barley. To get the smooth-awned character, the variety Lion or descendants of Lion were used and crossed with standard varieties. Lion had very poor malting quality, and the awn was tough and the hull brittle. In 1922, Dr. E.A. Lods at Macdonald College made the initial crosses using Lion as a parent. The progeny were useless for malting and peeled badly during threshing. It took 30 years of back-crossing and rigorous selection to produce Montcalm which was released in 1945. The irony was that harvesting methods had changed from binders and threshing machines to swathers and combines so that physical discomfort arising from rough awns was not as problematic when Montcalm was released. By this time, many growers preferred a rough-awned barley for producing better swaths!

From 1950 to 1961, Montcalm was the principal six-rowed variety in the central and eastern prairie region. Montcalm had little yield advantage over OAC 21 but had much improved malting quality.

The principal six-rowed malting cultivar in Alberta during this period was *Olli*. This variety was introduced from Finland by the Central Experimental Farm in Ottawa. Notable attributes of *Olli* were very early maturity and high barley saccharifying activity.

Major improvements in the malting quality of six-rowed varieties were achieved by W.H. Johnston at the Brandon Research Station with the releases of *Parkland* (1956), *Conquest* (1965) and *Bonanza* (1970). With each of these releases, there were distinct improvements in malting quality, and these varieties dominated in all regions of the Prairie Provinces where six-rowed barleys are grown.



The success of the program in Brandon in terms of improvement in malting quality was due to introduction of new, innovative techniques for screening early generation material by Dr. V.M. Bendelow at the Winnipeg Research Station. Innovations were many - including use of barley prediction tests, altered malting procedures and introduction of unique automated analytical procedures for screening large numbers of malted barley samples. The improvement in the quality of two-rowed malting barley cultivars can also be attributed, to a large degree, to Dr. Bendelow's novel screening procedures.

B. Two-Rowed Barley

If there is a "Cinderella" story in the area of malting barley improvement, it can be attributed to Harrington and the events leading to the release of this cultivar in 1981. The release of two-rowed malting barleys with Harrington-type quality has improved dramatically the potential for Canadian barley producers to take advantage of export market opportunities outside of North America.

Until recent years, growing of two-rowed barley was confined to the dry-land Palliser Triangle in southern Alberta and south-western Saskatchewan. *Hannchen*, licensed in 1923, predominated in this region until 1966. *Betzes*, released in 1960, soon replaced *Hannchen* and proved to be a popular variety grown on 25% of the total malting barley area. Two varieties, *Hector* (1973) and *Fairfield* (1976), with *Betzes*-type malting quality, were released by the Lethbridge Research

Argyle is a six-rowed malting cultivar released by the University of Manitoba in 1981. Although intended as a replacement for *Bonanza*, which dominated the six-rowed barley area since 1976, brewers demonstrated a reluctance to change varieties within their malt blends when *Bonanza* was readily available. However, *Bonanza* decreased from 35% of the malting barley area in 1986 to 24% in 1987 while a new two-rowed malting cultivar, *Harrington*, increased from 20% in 1986 to 43% in 1987. This change in varietal preference by barley growers should encourage brewers to purchase more *Argyle*.

Station. Although good dry-land barleys, these selections were subsequently grown only for feed purposes.

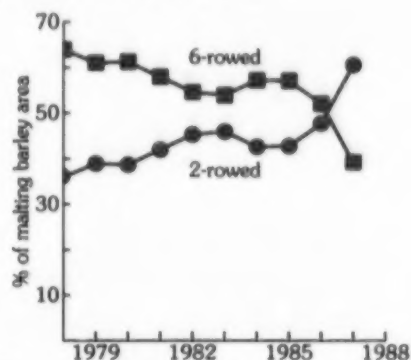
Klages, a two-rowed malting cultivar developed in Idaho, was introduced and released in Canada in 1977. *Klages* had much improved malting quality compared to *Betzes* and soon became the industry standard for quality. Intended for production on irrigated dry-land, *Klages* allowed the two-rowed malting barley area to expand into



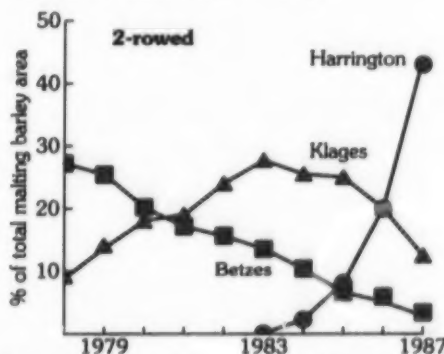
central Saskatchewan. However, Klages was not really adapted to Canadian growing conditions. It had later maturity and lower yield than adapted cultivars. Klages owed its popularity to its improved malting quality characteristics which were in demand in the marketplace.

When *Harrington* was released in 1981 by the University of Saskatchewan as a replacement for Klages, it was an instant success. *Harrington* is much better adapted agronomically and exhibits improved malting quality characteristics. In four growing seasons it has become the most popular barley variety in the Prairie Provinces - despite the fact that it lacks disease resistance for growing in the Eastern Prairie region. This latter problem is being addressed by research at the Winnipeg Research Station. A two-rowed malting cultivar, *Ellice*, completed commercial plant-scale malting and brewing trials in 1986 and will be released to growers in 1988. *Ellice* has unique, rapid malting

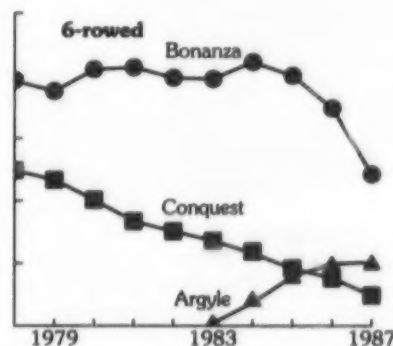
characteristics, and its quality profile is very similar to *Harrington*. But the real interest in *Ellice* is its potential to extend the two-rowed malting barley area into the Eastern Prairie region where rust and other foliar diseases prevail. If this program proves successful, it will make further in-roads into the popularity of six-rowed cultivars which currently predominate in this area.



Two-rowed and six-rowed cultivars as a percentage of the malting barley area.



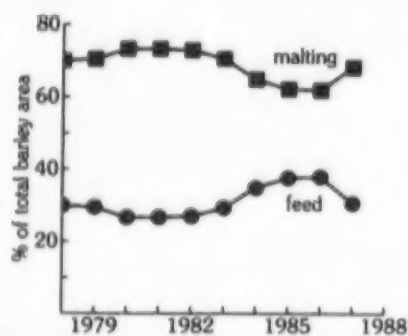
Malting cultivars as a percent of the malting barley area.





Barley improvement • the future

Emphasis in barley breeding for the Prairie region is shifting from interest in malting quality of six-rowed types to further improvement in two-rowed types. As Canadian producers rely to a large extent on dollars earned in export markets, it seems reasonable that emphasis on two-rowed cultivars is justified. Potential expansion of the two-rowed malting barley area into the Eastern Prairie region will have interesting positive economic impetus for domestic maltsters and brewers to utilize larger quantities of two-rowed barleys.

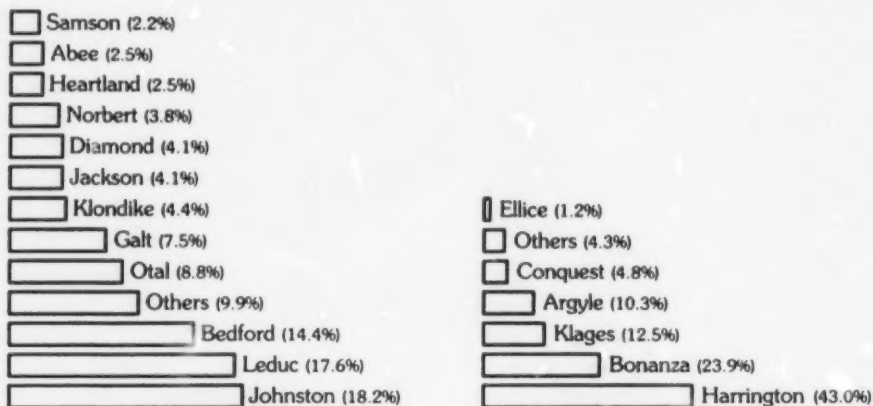


Malting and feed cultivars as a percentage of the total barley area.

six-rowed malting cultivars	Gateway	Argyle	two-rowed malting cultivars	Betzes	Harrington
	Conquest	BT 916*		Centennial	Ellice
	Bonanza	BT 917*		Klages	TR 479*
	Beacon			Elrose	TR 490*
six-rowed feed cultivars	Galt	Empress	two-rowed feed cultivars		
	Peguis	Tupper (H)**			
	Klondike	Heartland			
	Melvin	Jackson		Herta	Scout (H)**
	Bedford	Samson		Hector	Abec
	Johnston	Duke		Fairfield	Deuce
	Otal	Winchester		Norbert	
	Diamond	Virden			
	Leduc	Noble			

* Cultivars with interim registrations undergoing commercial, plant-scale malting and brewing trials.
 ** (H) - Hulless barley

Barley varieties registered for western Canada in 1987



Percent of total area of 1 499 000 hectares seeded to feed barley cultivars in 1987.

Percent of total area of 3 200 000 hectares seeded to malting barley cultivars in 1987.

Canadian malt plants

Company	Location	Year Established	Capacity (tonnes of malt)
Canada Malting Co. Ltd.	Montreal	1904	65 000***
Canada Malting Co. Ltd.	Winnipeg*	1907	35 000
Canada Malting Co. Ltd.	Calgary	1912	135 000***
Canada Malting Co. Ltd.	Toronto**	1928	52 000
Dominion Malting Ltd.	Winnipeg	1928	73 000
Canada Malting Co. Ltd.	Thunder Bay	1948	118 000***
Canada Malting Co. Ltd.	Toronto**	1968	43 000
Prairie Malt Ltd.	Biggar	1977	60 000

* Closed in 1985.
 ** Closed in 1987.
 *** Canada Malting Co. Ltd. is presently adding additional malting capacity to these facilities.



Suggested reading

1. *Barley in Canada*. CSTA Review, No. 11, 1936.
2. *Barley in Canada*. Agricultural Institute Review, March 1952.
3. *Minutes of the Associate Committee on Grain Research, 1925 to 1969*.
4. *My Daily Bread - An Autobiography*. J. Ansel Anderson.
5. *Silvered Reflections - An Autobiography*. R. Newton.
6. *Laboratory Malting and Barley Research in the Grain Research Laboratory - An Autobiography*. W.O.S. Meredith.
7. *Barley Improvement Institute. Annual Reports, 1949 to 1955*.
8. *A History of the Canadian Grain Commission, 1912-1987*. J. Blanchard, 1987.
9. *Brewing in Canada*. Brewers Association of Canada, 1965.
10. *100 Years of Brewing*. Arno Press, New York, 1974 (A reprinting of a book originally published in 1903).
11. *Canadian Research on Malting Barley*. J. Ansel Anderson. The Empire J. of Exptl. Agric. 12:219 (1944).
12. *Barley Survey*. H.C. Grant. His Majesty's Stationery Office, London, 1933.
13. *Canadian Barley Varieties - An Historical Review*. D.R. Metcalfe and D.E. LaBerge. Proc. Canadian Barley and Oilseeds Conf., p. 47, 1982.
14. *History of Barley Improvement in Canada*. T.J. Harrison. Proc. of Amer. Soc. Brewing Chem. Annual Meeting, p. 89, 1952.
15. *A Look at the Brewing Industry in America 100 Years Ago*. R.M. Halcrow. MBAA Tech. Quarterly 24:121 (1987).
16. *Malting Quality Selection Methods in Canadian Barley*. V.M. Bendelow. J. Amer. Soc. Brew. Chem. 35:81-88 (1976).
17. *Selection for Quality in Malting Barley Breeding*. V.M. Bendelow. Barley Genetics IV:181 (1981).

Liaison Activities

visitors to the Grain Research Laboratory

For the second consecutive year, the Grain Research Laboratory (GRL) accommodated over one thousand persons on tours of its premises. Of the total of 1,071 visitors (represented by 92 separate groups), 236 were from the following 18 countries: Algeria, Argentina, Australia, Colombia, England, Federal Republic of Germany, Finland, France, Japan, Korea, Mexico, People's Republic of China, Somalia, South Africa, U.A.R., U.S.A., U.S.S.R. and Yemen. Not included in the preceding list are countries represented by participants in Canadian International Grains Institute programs which incorporate tours of the GRL.

Of the 835 visitors from across Canada this year, 307 were grain producers and 77 were country elevator managers. As part of the activities in the celebration of the Seventy-fifth Anniversary of the Canadian Grain Commission (CGC), 157 persons were escorted on tours of the GRL during the "CGC Open House" held on June 24.

Two visiting researchers used GRL facilities for extended periods of time. Dr. X. Yin of the People's Republic of China, as holder of a travelling fellowship from the Natural Sciences and Engineering Research Council of Canada, carried out research on malting barley. Miss L.J. Malcolmson, a candidate for the PhD degree at the University of Manitoba, undertook research on durum wheat as the subject of her thesis. Both of these projects are continuing.



R. Matsuo (centre, seated) discussed alpha-amylase activity in durum wheat with processors from Japan.



Dr. X. Yin.

Agriculture Canada

Advisory Committee on Variety Registration

Meeting in Ottawa, ON.

R.R. Matsuo

Expert Committee on Fats, Oils and Other Lipids

1987 Meeting, Ottawa, ON.

J.K. Daun

Western Expert Committee on Grain Quality

1988 Meeting, Saskatoon, SK.

J.K. Daun

D.R. DeClercq

D.E. LaBerge

A.W. MacGregor

R.R. Matsuo

K.R. Preston

R. Tkachuk

K.H. Tipples

P.C. Williams

Eastern Expert Committee on Grain Quality

1988 Meeting, Ottawa, ON.

R.R. Matsuo

Western Computer Users Meeting

Regina, SK.

R. Tkachuk

American Association of Cereal Chemists

Annual Meeting, Nashville, TN.

J.E. Dexter

J.E. Kruger

R.R. Matsuo

K.R. Preston

K.H. Tipples

Board of Directors Meeting

Nashville, TN.

K.H. Tipples

Milling and Baking Technical Conference

Wichita, KS.

R.H. Kilborn

Starch Round Table, Nashville, TN.

X. Yin

American Barley Workers Conference,

Montana State University, Bozeman, MT.

D.E. LaBerge

B.A. Marchylo

(session

co-chairman)

**conference and
meeting attendance**

American Oil Chemists' Society	
Annual Conference, New Orleans, LA	J.A. Panford
Canadian Section,	
Third Conference, Winnipeg, MB	K.M. Clear
	R.M. Clear
	J.K. Daun
	D.R. DeClercq
	H.K. Howard
	P.B. Mazur
	B.A. Misener
	C.T. Thorsteinson
American Statistical Association	
Annual Meeting, San Francisco, CA.	J.C. Babb
Association of Applied Biologists	
Cereal Quality Conference, Cambridge, England	A.W. MacGregor
Association of Official Analytical Chemists	
Annual Meeting, San Francisco, CA.	T.W. Nowicki
Midwest Region Meeting, Fargo, ND	J.E. Dexter
	B.A. Marchylo
	T.W. Nowicki
	J.A. Panford
Workshop, Ottawa, ON.	D.G. Gaba
Association of Operative Millers	
Annual Conference, Toronto, ON	D.G. Martin
Joint Meeting with AACC, Albany, NY	K.R. Preston
Biotechnology Workshop	
London, ON.	D.E. LaBerge
Brewing and Malting Barley Research Institute	
Technical Committee Meeting, Winnipeg, MB	D.E. LaBerge
Canada-Mexico Grain Symposium	
Cocoyo, Mexico	K.H. Tipples
Canada-Japan Consultations on Canola	
Meeting in Japan	J.K. Daun
Canadian Institute of Food Science and Technology	
Annual Meeting, Hamilton, ON	R.R. Matsuo
Canadian International Development Agency	
Meeting in Ottawa, ON.	T.W. Nowicki

Canola Council of Canada Meeting in Saskatoon, SK	J.K. Daun
Crop Quality Council Annual Meeting, Manhattan, KS	K.R. Preston
Digital Equipment Company Users Society Symposium in Anaheim, CA.	R. Tkachuk
European Brewery Conference Madrid, Spain	A.W. MacGregor
Barley and Malt Group Meeting, Helsinki, Finland ..	A.W. MacGregor
Flax Research Priorities Conference Winnipeg, MB	J.K. Daun D.R. DeClercq
International Association for Cereal Science and Technology Executive Committee Meeting, Poznan, Poland	K.H. Tipples
International Gluten Workshop Budapest, Hungary.	R. Tkachuk
International Professional Communications Conference Winnipeg, MB	N.H. Barchuk
International Rapeseed Congress Poznan, Poland	J.K. Daun
International Standards Organization TC34/SC2 Committee Meeting, London, England. .	J.K. Daun
International Symposium on Biochemical Identification of Varieties Leningrad, USSR.	B.A. Marchylo
International Symposium on High Performance Liquid Chromatography Washington, DC	D.W. Hatcher
Manitoba Agronomists Annual Conference, Winnipeg, MB.	K.M. Clear R.M. Clear L.A. Cooke
Manitoba Institute of Agrologists Annual Meeting, Winnipeg, MB	L.A. Cooke

Manitoba Sunflower Committee Annual Tour	J.K. Daun
Microscopical Society of Manitoba Annual Meeting, Winnipeg, MB	L.A. Cooke
Master Brewers' Association of the Americas Annual Convention, Milwaukee, WI	D.E. LaBerge
Western Canada District Meeting, Saskatoon, SK	D.E. LaBerge
Near Infrared Reflectance Spectroscopy Users Fifth International Conference, Rockville, MD	P.C. Williams
Phytopathological Society of Canada Regional Meeting, Winnipeg, MB	R.M. Clear L.A. Cooke
Pittsburgh Conference and Exposition New Orleans, LA	J.E. Kruger
Professional Photographers of America Annual Convention, Chicago, IL	H. Zimberg
Red River Barley Day Grand Forks, ND	D.E. LaBerge
Safety and Health Conference Toronto, ON.	N.H. Barchuk
Spectroscopy Across the Spectrum Meeting in Norwich, England	P.C. Williams
Spring Wheat Quality Advisory Council Annual Meeting, Fargo, ND	K.R. Preston
Statistical Association of Manitoba Annual Meeting, Winnipeg, MB	J.C. Babb
Western Trace Organic Analysis Annual Workshop, Calgary, AB	T.W. Nowicki
Wheat/Barley Biotechnology Workshop Saskatoon, SK	D.E. LaBerge K.R. Preston
World Congress of Food Science and Technology Singapore	J.E. Kruger

Canadian Grain Commission	
Eastern and Western Grain Standards Committees . .	K.H. Tipples
Agriculture Canada	
Advisory Committee on Variety Registration	R.R. Matsuo
Canada Committee on Crop Production Services . . .	K.H. Tipples
Expert Committee on Fats, Oils and Other Lipids . .	J.K. Daun
Inter-Branch Working Group on Fumigants	T.W. Nowicki
Western Expert Committee on Grain Quality	K.H. Tipples (chairman)
	R.R. Matsuo (secretary)
	D.E. LaBerge
	K.R. Preston
	R. Tkachuk
Subcommittee on Barley and Oats	D.E. LaBerge (chairman)
	A.W. MacGregor
Subcommittee on Oilseeds and Special Crops . .	J.K. Daun (chairman)
	D.R. DeClercq
	R. Tkachuk
Subcommittee on Wheat	K.R. Preston (chairman)
	R.R. Matsuo
	P.C. Williams
Agricultural Institute of Canada	
Associate Editor, Canadian Journal of Plant Science.	K.R. Preston
American Association of Cereal Chemists	
Board of Directors	K.H. Tipples
Technical Committees:	
Amylase Methods	J.E. Kruger (co-chairman)
	A.W. MacGregor (co-chairman)
Bread Baking Methods	R.H. Kilborn
	K.R. Preston
Experimental Milling	J.E. Dexter
Methods for Grain Testing	P.C. Williams
Near-infrared Reflectance	P.C. Williams

committee membership

Pasta Products Analysis	J.E. Dexter
Physical Testing Methods	R.R. Matsuo
Quality Tests for Wheat and Flour	R.H. Kilborn
Total Dietary Fiber	K.R. Preston
Canadian Prairie Section	R. Tkachuk
	P.C. Williams
Publications Committee	D.W. Hatcher
Board of Editors, Cereal Chemistry	(secretary-treasurer)
Editorial Advisory Board, Cereal Foods World	J.E. Kruger
Osborne Medal Awards Committee	J.E. Dexter
	A.W. MacGregor
	R. Tkachuk
American Oil Chemists' Society	
Seed and Meal Analysis Committee	
Rapeseed and Canola Working Group	J.K. Daun
	(co-ordinator)
Canadian Section	J.K. Daun
	(vice-president)
Brewing and Malting Barley Research Institute	
Technical Committee	D.E. LaBerge
Canadian General Standards Boards	
Committee on Bakery and Cereal Products	R.R. Matsuo
Canadian Institute of Food Science and Technology	
1988 Conference Committee	R.R. Matsuo
	(chairman)
	J.E. Dexter
Codex Alimentarius, FAO, WHO	
Canadian Delegation	R. Tkachuk
	(chairman)
Federal Interdepartmental Committee on Pesticides Check	
Sample Program:	
Feeds/Grains Sub-program	T.W. Nowicki
	(co-ordinator)
Flax Council of Canada	
Market Development Committee	J.K. Daun

International Association for Cereal Science and Technology (ICC)	
Executive Committee, Technical Committee and General Assembly	K.H. Tipples
Working Groups on:	
Variety Identification by Electrophoresis	R. Tkachuk
Baking Tests	K.H. Tipples (chairman)
Determination of Wet Gluten	K.R. Preston
Particle Size	P.C. Williams
Methods of Protein Determination	R. Tkachuk
Sampling	P.C. Williams
Near-infrared Technology	P.C. Williams
International Committee on Pre-Harvest Sprouting	J.E. Kruger
International Rapeseed Congress (1991)	
Program Committee	J.K. Daun
International Standards Organization	
Canadian Advisory Committee TC34/SC4	K.H. Tipples (chairman)
Canadian Advisory Committee TC34/SC2	J.K. Daun
Journal of Cereal Science	
Board of Editors	K.H. Tipples
Manitoba Sunflower Committee	J.K. Daun
Master Brewers' Association of the Americas	
Housing Committee for 1988 Convention	D.E. LaBerge (chairman)
Microscopical Society of Canada	
Local Organizing Committee, 1987 Annual Meeting	L.A. Cooke (treasurer)
Red River Community College	
Advisory Committee for Chemical and Biochemical Technology	R. Tkachuk D.E. LaBerge

University of Manitoba Adjunct Professors, Department of Plant Science . . .	J.E. Kruger A.W. MacGregor R. Tkachuk P.C. Williams
Winnipeg Brewmasters Association Technical Committee	D.E. LaBerge (chairman)

oral presentations

At Canadian International Grains Institute

- K.H. Tipples
Introduction to the Grain Research Laboratory (presented three times)
Plant Breeding and the Marketplace
Wheat Quality: A Complex Subject
- R.M. Clear
Molds Found on Canadian Grains and Their Effect on Grades
Fusarium Head Blight in Canada
- L.A. Cooke
Preview of the Grading Factors Manual
Effects of Grading Factors Upon End-use Quality
- J.K. Daun
Oilseeds: New Developments in Canada - Technology and Marketing
- D.R. DeClercq
Oilseed Grading Factors and Related End-use Product Quality
Effects of Grading Factors on End-use Quality of Oilseeds
- J.E. Dexter
Relation of Wheat Class and Grade to End-use Quality
Effects of Grading Factors on End-use Quality of Wheat
- L.G. Dushnicky and A.W. MacGregor
Advanced Research Instruments
- D.W. Hatcher and V.J. Mellish
Varietal Purity Control

- R.H. Kilborn
Measurement of Sprout Damage
- R.H. Kilborn and J.E. Kruger
Apparatus for Measurement of Sprout Damage
- J.E. Kruger
Introduction to the Grain Research Laboratory
- D.E. LaBerge
Introduction to the Grain Research Laboratory (presented twice)
Effects of Grading Factors on End-use Quality of Malting Barley
- A.W. MacGregor
Introduction to the Grain Research Laboratory
The Barley Kernel: Composition and Structure
- R.R. Matsuo
Pasta Goods Manufacturing
- R.R. Matsuo and F.G. Paulley
The Relationship of Degrading Factors to End-product Quality
- B.A. Marchylo, V.J. Mellish and R. Tkachuk
Varietal Identification of Cereals
- T.W. Nowicki
Toxic Chemical Contaminants in Grain
Quality Control and Assurance of Canadian Grain for Toxic Chemical Contaminants
- J.A. Panford
Measurement of Protein and Moisture in Grain
- P.C. Williams
Wheat: Properties, Functionality and End-uses
Near Infrared Reflectance Spectroscopy

At conferences, meetings and seminars

R.M. Clear

Fusarium Head Blight in Eastern and Western Canada in 1987.

Regional Meeting, Phytopathological Society of Canada, Winnipeg, MB
Molds and Mildew.

United Co-op Meeting, London, ON

Fungi Associated with Mildewed Wheat.

GRL Seminar Series, Winnipeg, MB

Pink and Black Discolorations in Soybeans Grown in 1986 as Indicators of
the Possible Presence of Mycotoxins.

Canadian Section Meeting, American Oil Chemists' Society,
Winnipeg, MB

J.K. Daun

Quality Improvements and Problems in Rapeseed Breeding in Canada.

Helsinki University of Technology, Finland;

Food Research Institute, Norwich Laboratories, England;

Liverpool Polytechnical Institute, England

Chlorophyll in Rapeseed and Its Role as an Adjunct to Grading.

"Grow with Canola" Meetings in Prince Albert, SK and Morinville, SK

Determination of Oil Content in Canola and Flaxseed by a Modified Regrind
Procedure.

Canadian Section Meeting, American Oil Chemists' Society,
Winnipeg, MB

D.R. DeClercq

Determination of Total Glucosinolate Content in Canola Seed Using Thymol
Sulphuric Acid.

Canadian Section Meeting, American Oil Chemists' Society,
Winnipeg, MB

J.E. Dexter

Canadian Food Aid and Wheat Processing in French West Africa.

Canadian Prairie Section Meeting, American Association of Cereal
Chemists, Winnipeg, MB

Wheat Processing and Sightseeing in Colombia.

GRL Seminar Series, Winnipeg, MB

Durum Wheat Utilization.

Saskatchewan Agriculture/SeCan Seminars at Carlyle, Moose Jaw and
Rosetown, SK

The Grain Research Laboratory and Its Role in Wheat Marketing.
Saskatchewan Agriculture/SeCan Seminars at Carlyle, Moose Jaw and
Rosetown, SK

Quality Considerations for the Marketing of Durum Wheat.
Saskatchewan Agriculture/SeCan Seminars at Carlyle, Moose Jaw and
Rosetown, SK

J.E. Kruger

New Methods for the Determination of Alpha-amylase in Cereal-based
Products.

World Congress on Food Science and Technology, Singapore

The Grain Research Laboratory Paste Viscosity Indicator for Rapid
Determination of Alpha-amylase in Cereals.

Annual Meeting, American Association of Cereal Chemists, Nashville, TN

D.E. LaBerge

Breeding Priorities for Barley Quality.

Wheat/Barley Biotechnology Workshop, Saskatoon, SK

A.W. MacGregor

Barley Production and Utilization in Canada.

Presented three times at the Department of Plant Science, University of
Manitoba, Winnipeg, MB

The Chemistry and Biochemistry of Malting.

Short Course, Master Brewers Association of the Americas, Madison, WI

The Structure of Cereal Grains.

Short course, Master Brewers Association of the Americas, Madison, WI

The Grain Research Laboratory and Malting Barley Research.

Department of Agronomy, University of Wisconsin, Madison, WI

Biochemistry of Malting.

Alberta Section, Canadian Institute of Food Science and Technology,
Edmonton, AB

Fundamental and Applied Aspects of Barley Malting.

University of Alberta, Edmonton, AB

Six lectures on the production and utilization of Canadian barley.

Department of Plant Science, University of Manitoba, Winnipeg, MB

T.W. Nowicki

Some Safety Aspects of Grain, Flour and Bread.

Department of Food Science, University of Manitoba, Winnipeg, MB

K.R. Preston

Breeding Priorities for Wheat Quality.

Wheat/Barley Biotechnology Conference, Saskatoon, SK

Quality of CWRS Wheat Shipments - 1972 to 1986.

Annual Meeting, American Association of Cereal Chemists, Nashville, TN

Effects of Frost and Immaturity on Canadian Hard Red Spring Wheat.

Annual Meeting, American Association of Cereal Chemists, Nashville, TN

Quality of the 1987 Canadian Wheat Crop.

Joint Meeting, Association of Operative Millers/American Association of
Cereal Chemists, Albany, NY

R. Tkachuk

Basic Wheat Research at the Grain Research Laboratory.

GRL Seminar Series, Winnipeg, MB

Publications

- 567 MACGREGOR, A.W., LENOIR, C. Studies on Alpha-glucosidase in Barley and Malt. *J. Inst. Brew.* 93:334-337, 1987.
- 569 DAUN, J.K., BURCH, L.D., TKACHUK, R., MUNDEL, H.H. Composition of the Kernels of the Faveleira Nut (*Cnidocolus Phyllacanthus*). *JAOCS* 64(6):880-881, 1987.
- 571 MARCHYLO, B.A., MACGREGOR, A.W., KRUGER, J.E. Quantitative Analysis of Multiple Forms of Alpha-amylase Produced in Germinating Cereals. *Proc. Fourth Int. Symp. Pre-Harv. Sprout. Cereals*:522-533, 1986.
- 572 MARCHYLO, B.A., KRUGER, J.E. Degradation of Starch Granules in Maturing Wheat and Its Relationship to Alpha-amylase Production by the Embryo. *Proc. Fourth Int. Sym. Pre-Harv. Sprout. Cereals*:483-493, 1986.
- 589 PRESTON, K.R., KILBORN, R.H., DEXTER, J.E. Effects of Starch Damage and Water Absorption on the Alveograph Properties of Canadian Hard Red Spring Wheats. *J. CIFST* 20(2):75-80, 1987.
- 590 DEXTER, J.E., PRESTON, K.R., KILBORN, R.H. Milling and Baking Qualities of Some Canadian Wheat Classes Alone and in Blends With Brazilian Wheat Under Brazilian Processing Conditions. *J. CIFST* 20(1): 42-49, 1987.
- 591 ABRAMSON, D., CLEAR, R.M., NOWICKI, T.W. *Fusarium* Species and Trichothecene Mycotoxins in Suspect Samples of 1985 Manitoba Wheat. *Can. J. Plant Sci.* 67:611-619, 1987.
- 592 DAUN, J.K., DECLERCQ, D.R. Quality of Yellow and Dark Seeds in *Brassica campestris* Canola Varieties Candle and Tobin. *JAOCS* 65(1):122-126, 1988.
- 593 DEXTER, J.E., PRESTON, K.R., COOKE, L.A., MORGAN, B.C., KRUGER, J.E., KILBORN, R.H., ELLIOTT, R.H. The Influence of Orange Wheat Blossom Midge (*Sitodiplosis mosel lana Gehin*) Damage on Hard Red Spring Wheat Quality and the Effectiveness of Insecticide Treatments. *Can. J. Plant Sci.* 67:697-712, 1987.
- 594 LABERGE, D.E., MARCHYLO, B.A. Changes in Beta-amylase Enzymes of Barley During Malting. *J. Amer. Soc. Brew. Chem.* 45(4):140-145, 1987.
- 595 DEXTER, J.E., MATSUO, R.R., MARTIN, D.G. The Relationship of Durum Wheat Test Weight to Milling Performance and Spaghetti Quality. *Cereal Foods World* 32(10):772-777, 1987.

scientific papers

- 596 MARCHYLO, B.A. Barley Cultivar Identification by SDS Gradient PAGE Analysis of Hordein. *Can. J. Plant Sci.* 67:927-944, 1987.
- 597 MARCHYLO, B.A. Identification of Canadian and American Wheat Cultivars by SDS Gradient PAGE Analysis of Gliadin and Glutenin Subunits. *Can. J. Plant Sci.* 67:945-952, 1987.
- 598 TKACHUK, R., KUZINA, F.D., REICHERT, R.D. Analysis of Protein in Ground and Whole Field Peas by Near-infrared Reflectance. *Cereal Chem.* 64(6):418-422, 1987.
- 599 WILLIAMS, P.C., KILBORN, R.H., VOISEY, P.W., KLOEK, M. Measuring Wheat Hardness by Revolutions per Minute Reduction. *Cereal Chem.* 64(6):422-427, 1987.
- 601 MARCHYLO, B.A., HATCHER, D.W., KRUGER, J.E. Identification of Wheat Cultivars by Reversed-phase High Performance Liquid Chromatography of Storage Proteins. *Cereal Chem.* 65(1):28-40, 1988.
- 605 TKACHUK, R., MELLISH, V.J., DAUN, J.K., MACRI, L.J. Determination of Chlorophyll in Ground Rapeseed Using a Modified Near Infrared Reflectance Spectrophotometer. *JAOCS* 65(3):381-385, 1988.

**miscellaneous
papers**

- M146 MACGREGOR, E.A., MACGREGOR, A.W. Studies of Cereal Alpha-amylase Using Cloned DNA. *CRC Crit. Rev. Biotech.* 5(2):129-142, 1987.
- M147 MACGREGOR, A.W. Alpha-amylase, Limit Dextrinase and Alpha-glucosidase Enzymes in Barley and Malt. *CRC Crit. Rev. Biotech.* 5(2):117-128, 1987.
- M148 DEXTER, J.E., TIPPLES, K.H. Wheat Milling at the Grain Research Laboratory - Part 1. Milling Flour and Feed 160(6):22-27, 1987.
- M149 DEXTER, J.E., TIPPLES, K.H. Wheat Milling at the Grain Research Laboratory - Part 2. Milling Flour and Feed 160(7):16-20, 1987.
- M150 DEXTER, J.E., TIPPLES, K.H. Wheat Milling at the Grain Research Laboratory - Part 3. Milling Flour and Feed 160(8):18-23, 1987.
- M151 DEXTER, J.E., TIPPLES, K.H. Wheat Milling at the Grain Research Laboratory - Part 4. Milling Flour and Feed 160(9):14-21, 1987.

B.A. MARCHYLO and J.E. KRUGER. Methods for the Purification and Separation of Cereal Enzymes and their Multiple Forms. In: *Enzymes and Their Role in Cereal Technology*, published by the American Association of Cereal Chemists, St. Paul, Minnesota, 1987. Chapter 2.

J.E. KRUGER and D.R. LINEBACK. Carbohydrate Degrading Enzymes in Cereals. In: *Enzymes and Their Role in Cereal Technology*, published by the American Association of Cereal Chemists, St. Paul, Minnesota, 1987. Chapter 5.

R.R. MATSUO. The Effect of Enzymes on Pasta and Noodle Products. In: *Enzymes and Their Role in Cereal Technology*, published by the American Association of Cereal Chemists, St. Paul, Minnesota, 1987. Chapter 11.

chapters in books

Sixtieth Annual Report • 1986-87 Report of the Grain Research Laboratory

Cargo Bulletins • Red Spring Wheat editions are published in an English-French-German-Spanish version, an English-Japanese version (suffix "J") and an English-Chinese version (suffix "C"). Amber Durum Wheat editions are published in an English-French-German-Italian version.

236 Quality of Canadian Grain Exports 1986-87, Red Spring Wheat, second quarter (Nov. 1 to Jan. 31)

237 Quality of Canadian Grain Exports 1986-87, Amber Durum Wheat, first and second quarters (Aug. 1 to Jan. 31)

238 Quality of Canadian Grain Exports 1986-87, Red Spring Wheat, third quarter (Feb. 1 to Apr. 30)

239 Quality of Canadian Grain Exports 1986-87, Red Spring Wheat, fourth quarter (May 1 to July 31)

240 Quality of Canadian Grain Exports 1986-87, Amber Durum Wheat, third and fourth quarters (Feb. 1 to July 31)

- Quality of Canadian Rapeseed and Flaxseed Cargoes, 1986-87 Crop Year

241 Quality of Canadian Grain Exports 1987-88 Red Spring Wheat, first quarter (Aug. 1 to Oct. 31)

periodicals

Crop Bulletins •

170 Quality of Canadian Wheat 1987

- Quality of Western Canadian Canola and Flaxseed 1987 - Preliminary Report

171 Quality of Western Canadian Canola 1987

172 Quality of Western Canadian Flaxseed 1987

173 Quality of Western Canadian Sunflower 1987

- Quality of Canadian Soybean 1987

Staff

K.H. Tipples, B.Sc., Ph.D.

Director

D.J. Ramsay
N.H. Barchuk

Secretary
Special Assistant
to the Director
(Research)



D.E. Routley*, N.L. Morgan

Assistant Director
(Administration)

K.A. Tait
G.A. McLean, B.M. Mercer*,
M.J. Pewarchuk, M.C. Cyr
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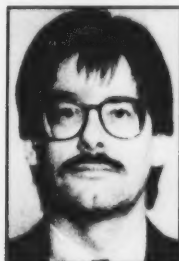
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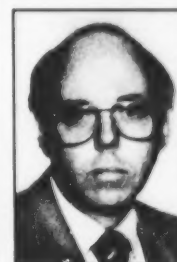
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**wheat varietal
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- * Separated from staff during this reporting period.
- ** Career-oriented Summer Employment Program (COSEP).

*La version française de cette publication s'intitule
Laboratoire de recherches sur les grains
Rapport de 1987-1988
et s'obtient sur demande
auprès de la Commission canadienne des grains,
1404 - 303 rue Main, Winnipeg (Manitoba) R3G 3G8.*

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Catalogue No. A91-2/1988
ISSN 0317-1892